

Development of a Particle Number-Based Test Method for Air Purifying Particulate Respirators

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Background

- The National Institute for Occupational Safety and Health (NIOSH) certification testing of air purifying particulate respirators, including filtering facepiece respirators (FFRs) employ solid (NaCl) and liquid (dioctyl phthalate, DOP) aerosols to test the filtration performance
- N Type respirators (N95, N99 and N100)
 - Polydisperse NaCl Aerosol Test - TSI 8130
 - Count median diameter (CMD) 75 ± 20 nm and GSD <1.86
 - Charge neutralized aerosols - 85 L/min flow rate
- R Type (R95, R99 and R100) and P Type (P95, P99 and P100) respirators
 - Polydisperse DOP Aerosol Test - TSI 8130
 - CMD 185 ± 20 nm and GSD <1.60
 - Charge neutralized aerosols - 85 L/min flow rate
- Penetration levels measured using photometric technique with a TSI 8130 Automated Filter Tester
- Photometric methods lack sensitivity to measure particles <100 nm size
- The most penetrating particle size (MPPS) for electret filters are generally in the 50 nm range (Fig 1., Shaffer, R. and Rengasamy, S., 2009)
- A new “worst case” test method for the MPPS has been suggested to ensure filters maintain filtration performance commensurate with their ratings for all workplace aerosol sizes including nanoparticles

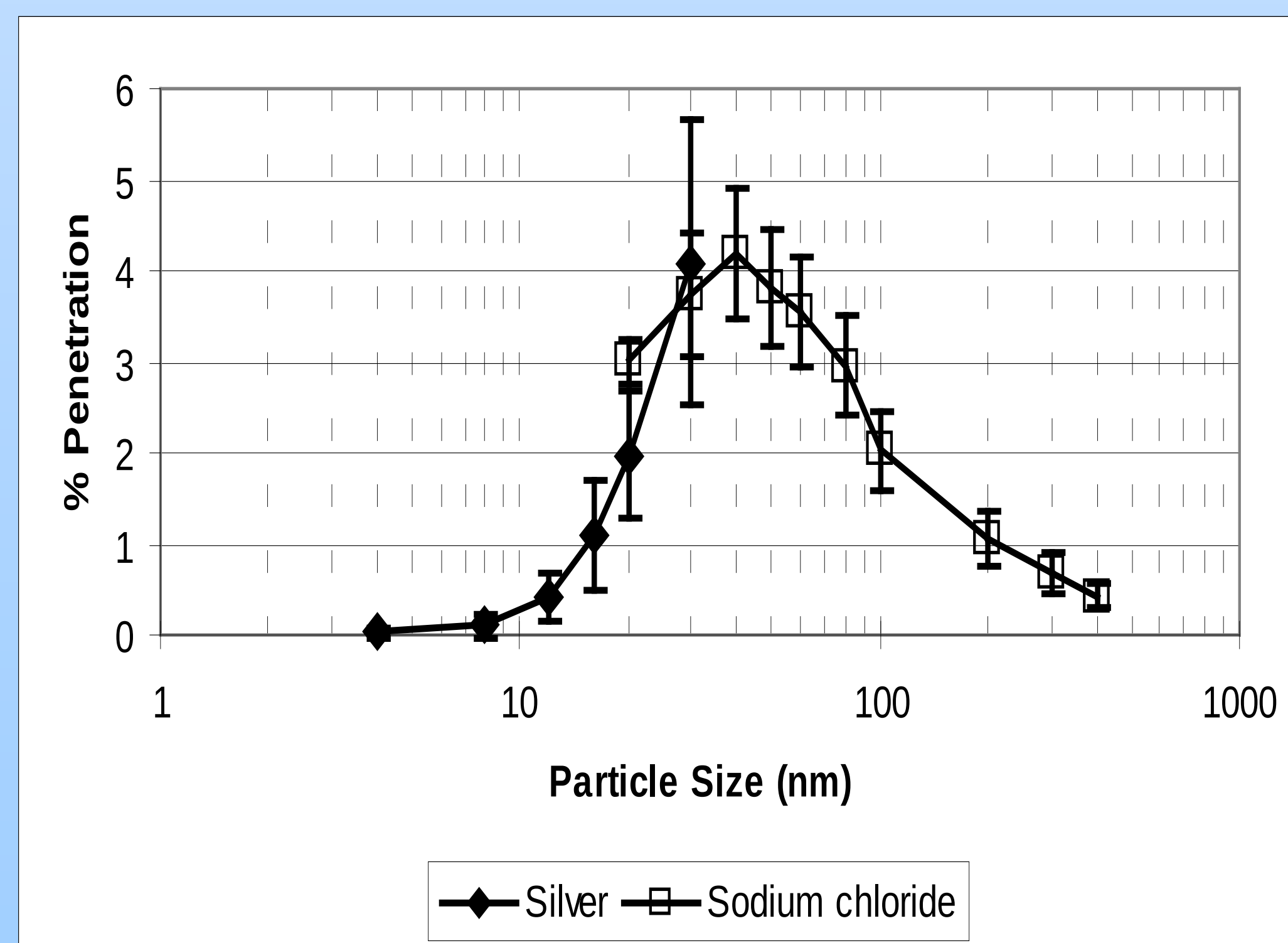


Fig 1. Monodisperse silver (4-30 nm) and monodisperse NaCl (20-400 nm) aerosol particle penetration levels for one model of an N95 FFR. Each data point represents the mean and standard deviation from evaluation of five respirators.

Objectives

- To evaluate the current NIOSH photometric (TSI 8130) test methods using NaCl and DOP aerosols with a particle number-based test method for the same aerosols
- To develop a number-based test method using aerosols with a CMD value in the most penetrating particle size range (<100 nm)
- Provide an alternate test method for consideration in future revisions of 42 CFR Part 84

Proposed Criteria

- The ideal number-based test method should:
 - Measure penetration of particles in the MPPS range to offer a more stringent challenge
 - Reasonable cost (Similar to the TSI 8130)
 - Operate similarly to the TSI 8130 in terms robustness and ease of use
 - Be able to conduct testing with either constant or cyclic flow.

Proposed Milestones

- Phase 1: Literature review / Stakeholder meeting (2010)
- Phase 2: Research proposal submission (2010)
- Phase 3: Prototype equipment development (2011)
- Phase 4: Benchmark testing / Compare with existing methods (2011)
- Phase 5: Reports/ Presentations (2012)

Key Partners and Stakeholders

- Aerosol equipment manufacturers
- Respirator manufacturers and users
- Industrial hygienists
- NIOSH laboratories
- Universities

Preliminary Studies

Photometric vs. Particle number-based method

- Polydisperse NaCl aerosols
 - CMD 75nm and GSD <1.86
 - Charge neutralized aerosols
 - 85 L/min flow rate
- Photometric test - TSI 8130
- Particle number-based test method – Ultrafine condensation particle counter (UCPC, TSI 3776)

Test method

- Measure penetration levels for N95 FFRs using NaCl aerosols (TSI 8130 - Photometric method)
- Measure penetration levels for another set of FFRs using the same aerosols with two UCPCs as shown in Figure 2 (Particle number-based test method)
- Briefly, TSI 8130 test aerosols were passed into the top chamber of box A and then to a filter test box B through two dilution stages. The downstream sample was allowed to reach the bottom chuck of TSI 8130 through the bottom chamber of box A. Samples upstream and downstream of the respirator test box B were analyzed for particle concentration using two UCPCs simultaneously. The dilution stages were used to bring the output concentration of the TSI 8130 to the detectable range of the UCPCs (TSI 3776).

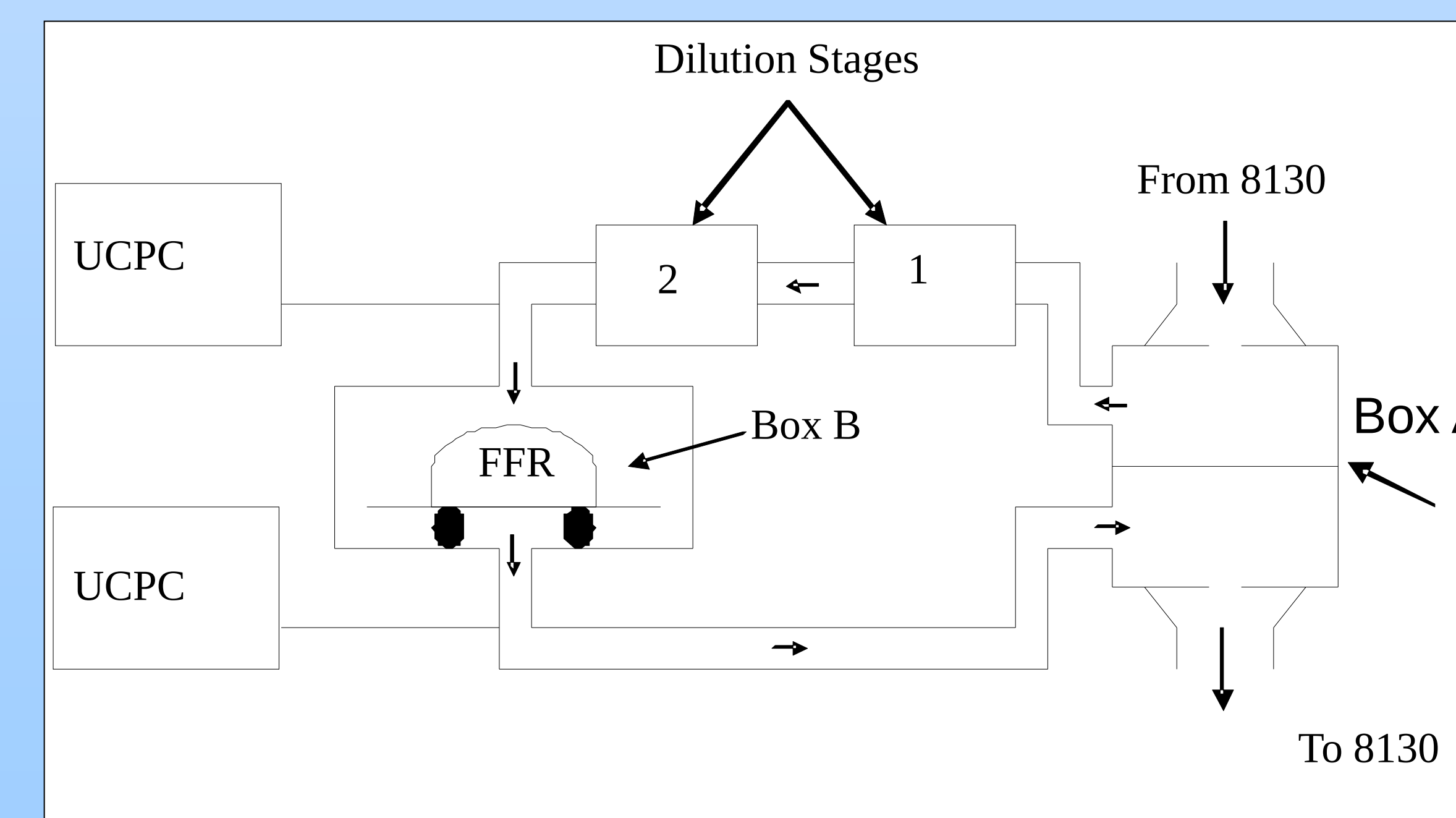


Fig 2. Particle number-based test method for TSI 8130 NaCl aerosols.

Results

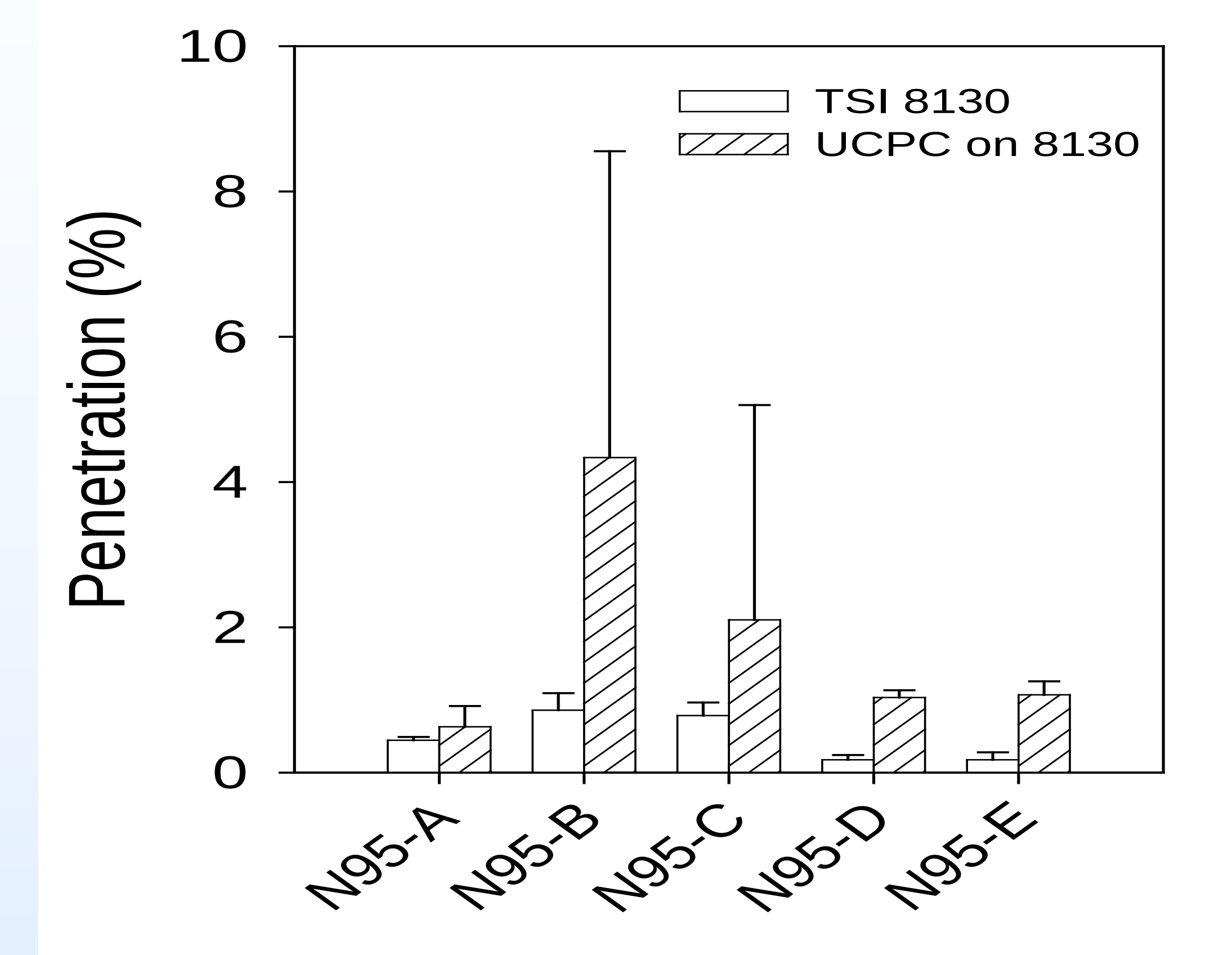


Fig 3. Penetration levels for the three FFR samples from five N95 models at sealed conditions. (empty bars –TSI 8130 and hatched bars - UCPC).

Initial Findings

- Percentage penetrations for N95 FFRs measured by a particle number-based test system for the NaCl aerosols (CMD 75 ± 20 nm) were two to six-fold higher than the penetration levels measured by the TSI 8130 photometric test method

Next steps

- Standardize particle number-based test method using polydisperse NaCl and DOP aerosols with 50 nm CMD at 85 L/min flow conditions
- Develop particle number-based bench mark test(s) for NIOSH-approved N, P, and R type particulate respirators using NaCl and/or DOP aerosols
- Stakeholder meeting
- Finalize research proposal and submit for external peer review

References

- Shaffer, R. and Rengasamy, A. (2009) J Nanopart Res 11:1661-1672

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